PB85-124667

Floating Cover Systems for Waste Lagoons Potential Application at Old Inger Site, Louisiana

JRB Associates, Inc., McLean, VA

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Nov 84

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA-600/D-84-273
November 1984

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Mark L. Evans and John P. Meade
JRB Associates
McLean, Virginia

Anthony N. Tafuri
U.S. Environmental Protection Agency
Oil and Hazardous Materials Spills Branch
Edison, New Jersey

EPA Contract 68-03-3113

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA-600/D-84-273	2.	3. RECIPIENT'S ACCESSION NO. PB85 124667
4. TITLE AND SUBTITLE "Floating Cover Systems for Waste Lagoons: Potential Application at Old Inger Site, Louisiana"		5. REPORT DATE November 1984 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) M.L. Evans and J.P. Meade, JRB Associates A.N. Tafuri, EPA		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS JRB Associates 8400 Westpark Drive McLean, VA 22102		10. PROGRAM ELEMENT NO. CBRD1A 11. CONTRACT/GRANT NO. 68-03-3113
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Envir. Research Lab. - Cinn. OH Office of Research & Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Conference Paper 14. SPONSORING AGENCY CODE EPA/600/14
15. SUPPLEMENTARY NOTES Anthony N. Tafuri (201) 321-6604		

16. ABSTRACT

Hazardous liquids are impounded in pits, ponds, and lagoons at many uncontrolled hazardous waste sites across the country. As the ranking, remedial investigations, and feasibility studies proceed at these sites, many of the lagoons gradually fill with rainwater and threaten to overflow, thus requiring frequent pumpdown of the impounded liquids to prevent overtopping and subsequent transport and treatment of the collected wastes. This practice can be expensive, costing up to $0.40/gallon depending on the chemicals and haul distances involved. The overall objective of this project was to investigate alternative methods for preventing overtopping of a lagoon, with specific application to the Old Inger Site in Darrow, Louisiana. Activities included: (1) a survey of cover/liner industry representatives and a comprehensive literature search to identify the cost and engineering variables of floating covers; and (2) cost and technical comparisons of floating covers with four alternatives (including no action, pumping and treatment, air supported structures, and inflatible covers) for addressing overtopping at the Old Inger Site. These activities resulted in a complete state-of-the-art deliniation of flexible floating covers including the age of the technology, materials used, construction techniques, installation costs, patents, current use profiles and applicability to hazardous waste control problems.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 19
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

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Mark L. Evans and John P. Meade

JRB Associates

McLean, Virginia

Anthony N. Tafuri

U.S. Environmental Protection Agency

Oil and Hazardous Materials Spills Branch

Edison, New Jersey

INTRODUCTION

There are many pits, ponds, and lagoons at uncontrolled hazardous waste sites across the nation. With the accumulation of sufficient rainwater, these impoundments can overflow, resulting in the release of their chemical laden contents to the surrounding environment. One approach to this problem involves pumping, transporting, and treating enough of the impounded material to create a safe margin of freeboard between the remaining liquid and the top of the containment structure. These pumpdown/treatment measures are considered temporary however, and are usually initiated to prevent damage to the environment while the site is undergoing investigation and ranking for eventual remedial action. They also can be expensive, costing between $0.10 and $0.40/gallon (1), and especially expensive if pumpdown/-treatment is required several times before a final action can be undertaken at a site.

To address this problem, the Oil and Hazardous Materials Spills Branch (OHMSB) of EPA assembled cost and technical information on methods to prevent rainwater from entering these impoundments. The resulting report on spillage control methods for waste lagoons (2) concluded that conventional structural covers (i.e., metal buildings, air supported structures, and cable structures) are not generally cost-effective for preventing overtopping of waste lagoons unless there are unusual circumstances that increase pumpdown/treatment costs. The report recommended the investigation of innovative structures, such as floating covers, as an alternative to pumping, transport, and treatment of impounded liquids.

In response to the above-mentioned recommendation, and a request from EPA Region VI for information on this technology, OHMSB directed JRB Associates to: 1) perform a state-of-the-art review of floating cover systems, and 2) recommend specific alternatives to prevent the potential overtopping of a waste lagoon at the Old Inger site near Darrow, Louisiana. This paper documents the result of these efforts, and includes information obtained from actual site visits and from 15 cover/liner manufacturers and installers (3-20).

TECHNOLOGY DEVELOPMENT AND CURRENT USES

Floating covers were initially developed as an inexpensive method for covering potable water reservoirs to eliminate contamination from surface runoff and organic debris. The first patent was issued in 1967 to Globe Linings, Inc. for a design that allowed for extreme fluctuations in liquid levels and drainage of accumulated rainwater from the cover surface (28).

These covers were installed in many reservoirs during the late 1960s and early 1970s by various installation companies across the country. The first covers were made of either butyl rubber or a synthetic polymer called Ethylene-propylene-diene-monomer (EPDM), and were fitted with butyl rubber floats that required inflation (12, 26). Current floating covers are composed of Hypalon or chlorinated polyethylene (CPE); however, other materials are also used for special projects (3,20). The old air-inflated rubber floats have been replaced by closed cell polyethylene floats.

In 1976, two additional patents were issued: one to Burke Industries, Inc.; the other to Globe Linings, Inc. (29, 30). The Burke patent presented a new method for draining rainwater from a floating cover while the Globe patent presented a new system for collecting gases from beneath covers placed over biodegradation ponds.

Up to the present time, Globe Linings, Inc. has installed approximately 200 covers, while Burke and five other companies have installed about 100 more (12,16). These covers have ranged in size from about 15,000 ft^2 to about 700,000 ft^2; however, larger covers also have been installed. One cover, now under construction in the Los Angeles, California area, spans 2,000,000 ft^2 (3-20).

According to industry officials, approximately 80 to 85 percent of all floating covers have been constructed over potable water reservoirs (12, 16). The remaining 15 to 20 percent have been used on biodegradation facilities, slaughterhouse waste lagoons, chemical treatment ponds, toxic waste lagoons, and fish hatchery ponds (12, 16). The covers for

biodegration facilities were developed to collect methane gas for use in boilers or electric generators. Odor control was cited as the main reason for covering pits at slaughterhouses. Fish hatchery ponds were covered to prevent fishkilling algal blooms. Chemical treatment ponds and toxic waste lagoons were covered to prevent overtopping due to precipitation. Due to the proprietary nature of these activities very little data were available on the types of chemicals or facilities involved in covering waste lagoons.

Regardless of where they have been placed, floating cover systems have shown a remarkable resistance to the elements at a very low cost. Average costs ranged between \$2.50 and \$3.50/ft^2 (3-20); much lower than other available methods for covering large bodies of liquid (2). In addition, many of the representatives contacted stated that a 20 year guarantee was provided for their system (6, 7, 12, 19, 20). The durability of floating covers is exemplified by a cover installed on a potable reservoir in Fort Saint John, British Columbia (12) which withstood the forces of 4 feet of ice and $-40^{\circ}F$ temperatures for 2 months. (The temperature dropped to $-65^{\circ}F$ for 3 weeks during that 2 month period.) Two other covers in Mobile, Alabama have been unaffected by winds up to 150 mph (18).

DESIGN OF FLOATING COVERS

As mentioned in the previous section, there are two patented designs for floating covers and an additional patent for the associated gas collection system. These designs, with slight modifications, have been utilized in virtually every floating cover system installed to date.

The Globe Design

The Globe design is primarily based on a rainwater collection sump that forms around the perimeter of the cover during rain events. Rainwater is directed toward this sump by various configurations of foam floats inserted and sealed into special pockets in the cover. The most common configuration consists of one long center float attached perpendicularly to smaller, lateral floats at about 36-foot centers (Figure 1). After the perimeter sump fills with water, it is drained either by random pumping with a portable pump or by installing a flexible perforated hose in the area of the fold formed by the collected water. On large reservoirs, vertical cables have been strung from the reservoir bottom and attached to the cover to stabilize it against wind action.

The patented Globe gas collection system is designed for connection to the foam floats on the Globe cover. However, since all cover designs use the same type of floats, the Globe gas collection system could be fitted to almost any floating cover. The gas collection system consists of several air chambers formed at various points along the cover flotation system (Figure 2). Each chamber is covered by the floating cover material and is equipped with openings that allow gases to flow up through the air chamber from the triangular-shaped space formed between the cover, the covered liquid, and the side of the float. The upper end of the air chamber is connected to a short standpipe, and then to a manifold pipe to allow pumping of gases.

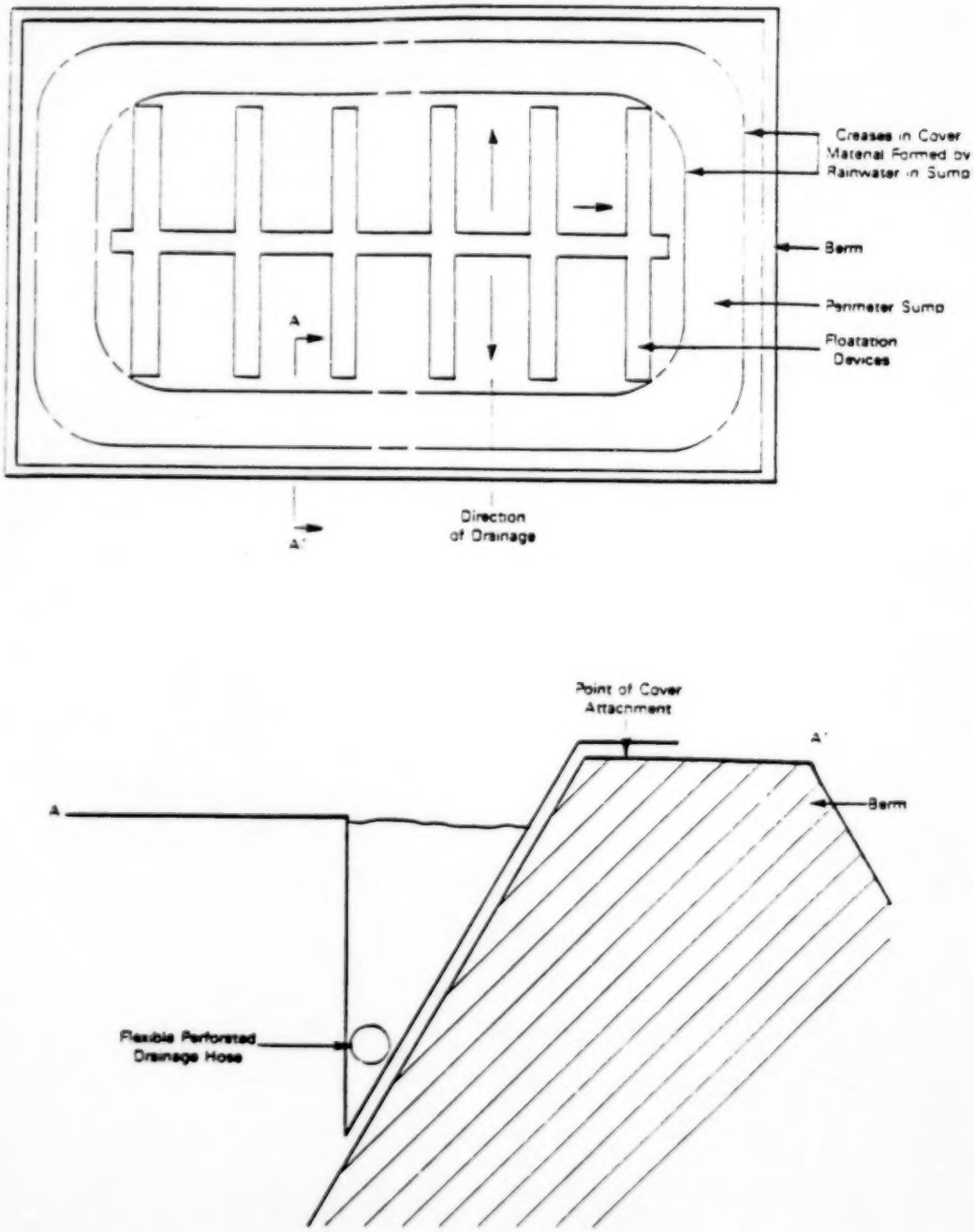

Figure 1. Schematic Overview and Cross-Section of a Floating Cover Incorporating the Patented Globe Design.

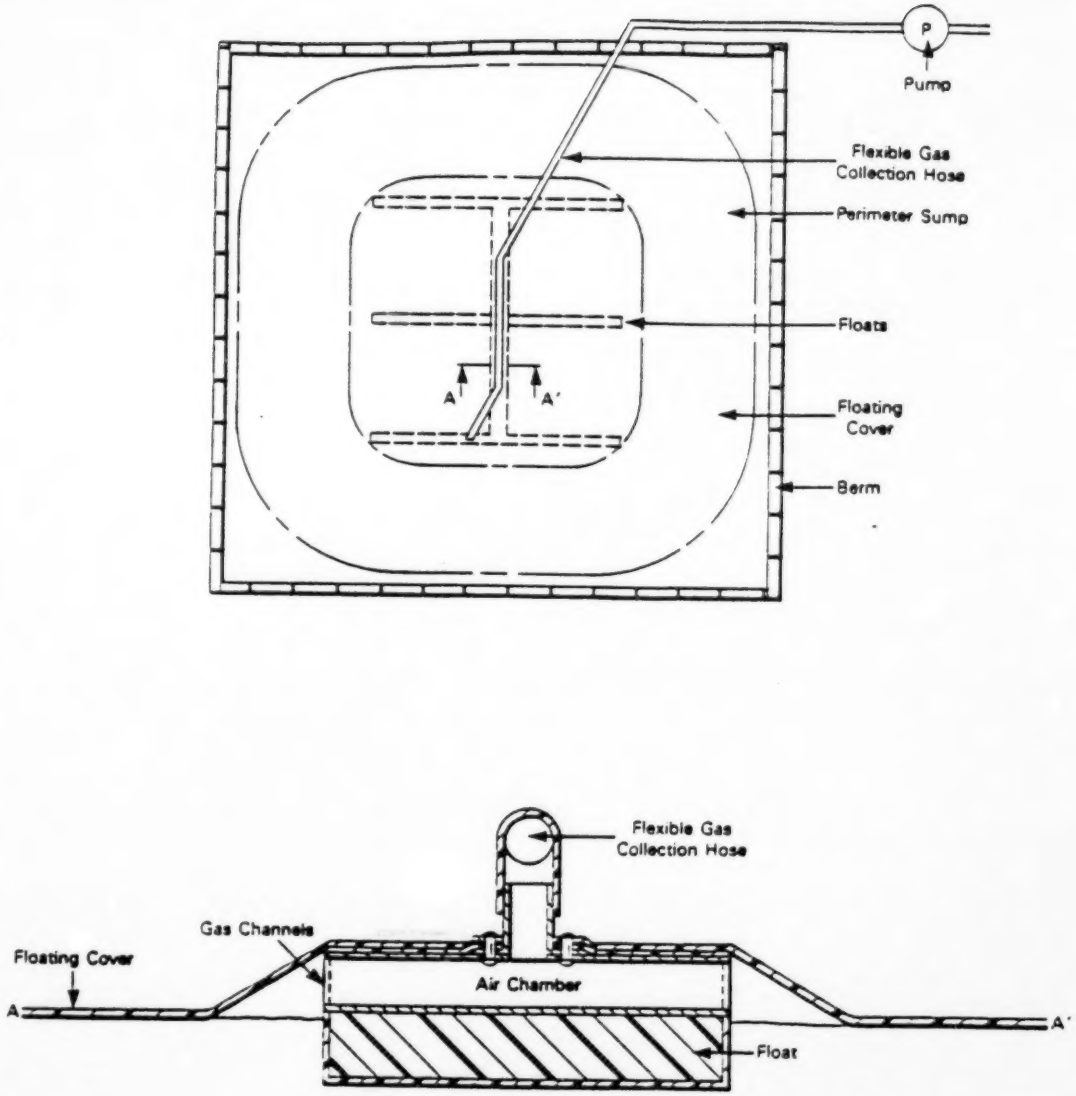

Figure 2. Schematic Overview and Cross-Sections of a Patented Globe Floating Cover and Gas Collection System Design (Redrawn from Kays, 1976, Patent Number 3,980,199).

The Burke Design

The Burke design, patented in November of 1976, presents a completely different method of draining rainwater from the floating cover. It consists of channels in the middle of the cover created by strings of segmented sand-filled tubes that are held at a constant depth beneath the cover by floats on either side of the channel (Figure 3). The sand-filled tubes lie underneath and are connected to flexible perforated collection tubes. Rainwater, after striking the cover, drains through openings in the floats and into the collection channels; then it is pumped off through the collection tubes. The dimensions for each component of the system are determined through a few simple equations that are based on the dimensions of the area to be covered. With the exception of the sand-filled tubes, the Burke design can be built with the same materials used in the Globe design.

MATERIALS OF CONSTRUCTION

About 90 percent of all floating covers are made with reinforced Hypalon, either 36 or 45 mils in thickness (3-20). Hypalon is used because it is resistant to most chemicals and weather conditions, easy to seam in the field, and among the least expensive when compared to other materials. After Hypalon was developed, EPDM and butyl rubber were abandoned due to cracking and seaming problems. The second most popular material for floating covers is reinforced 36 or 45-mil CPE (19). This material costs about the same as Hypalon ($0.50 to $0.70/ft^2) but is not as easy to seam in the field, nor as durable. Because of these drawbacks, the use of CPE for covers is declining (19).

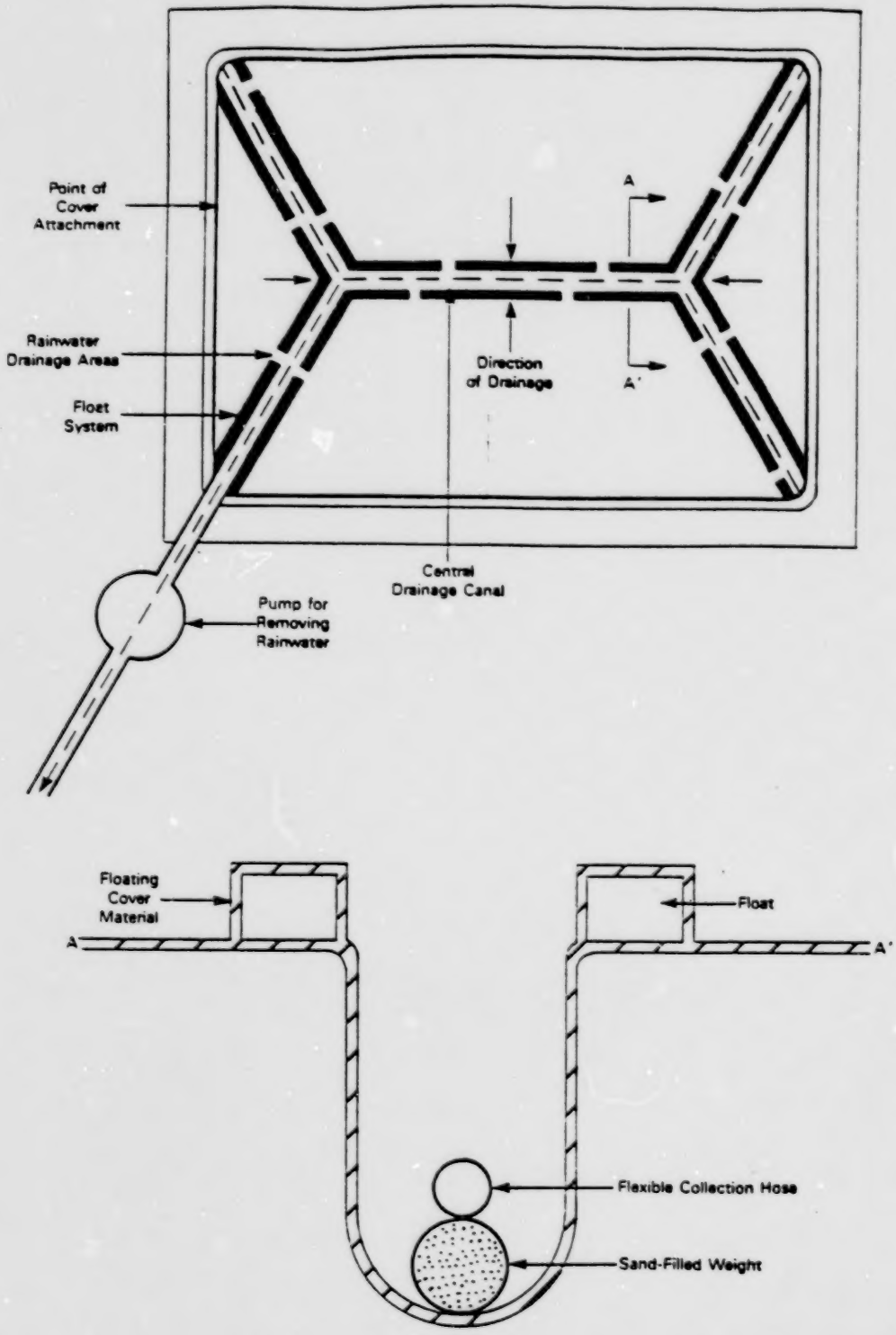

Figure 3. Schematic Overview and Cross-Section of a Floating Cover Incorporating the Patented Burke Design (Redrawn from Burke, et. al., 1976, Patent Number 3,991,900).

The main limitation of Hypalon, i.e., its low resistance to oil derivitives such as kerosene, diesel fuel, and hydraulic fluids, led to the development of three other membranes. Two of these, used by Globe Linings, Inc., are called OR-EPA and HR-EPA (12). Globe had no organized test data on either of these materials and declined to release the name of the manufacturer; however, a sample of OR-EPA appeared to be more resistant to stretching than samples of Hypalon. A representative of Globe stated that HR-EPA is stronger and resists more chemicals that OR-EPA, which is stronger and resists more chemicals than Hypalon (12). These tougher materials are priced accordingly, with HR-EPA costing about $\$1.70/ft^2$ and OR-EPA costing about $\$1.50/ ft^2$ (12). The Globe representative also stated that HR-EPA and OR-EPA are more difficult to field seam than Hypalon (12).

The other alternative to Hypalon is XR5 made by the Shelterite Company. This material is highly resistant to a wide range of chemicals, but, like the other alternatives to Hypalon, XR5 is more difficult to field seam and is about twice as expensive.

APPLICABILITY OF FLOATING COVERS AT THE OLD INGER SITE

The Old Inger Site is located near Darrow, Louisiana, between Louisiana Highway 75 and the Mississippi River levee (Figure 4). Once an oil reclamation plant, this site was abandoned in 1978 and is now on the Superfund National Priority List. It has been the subject of a remedial investigation and will receive a state-led remedial action in late 1985 or early 1986 (2, 25).

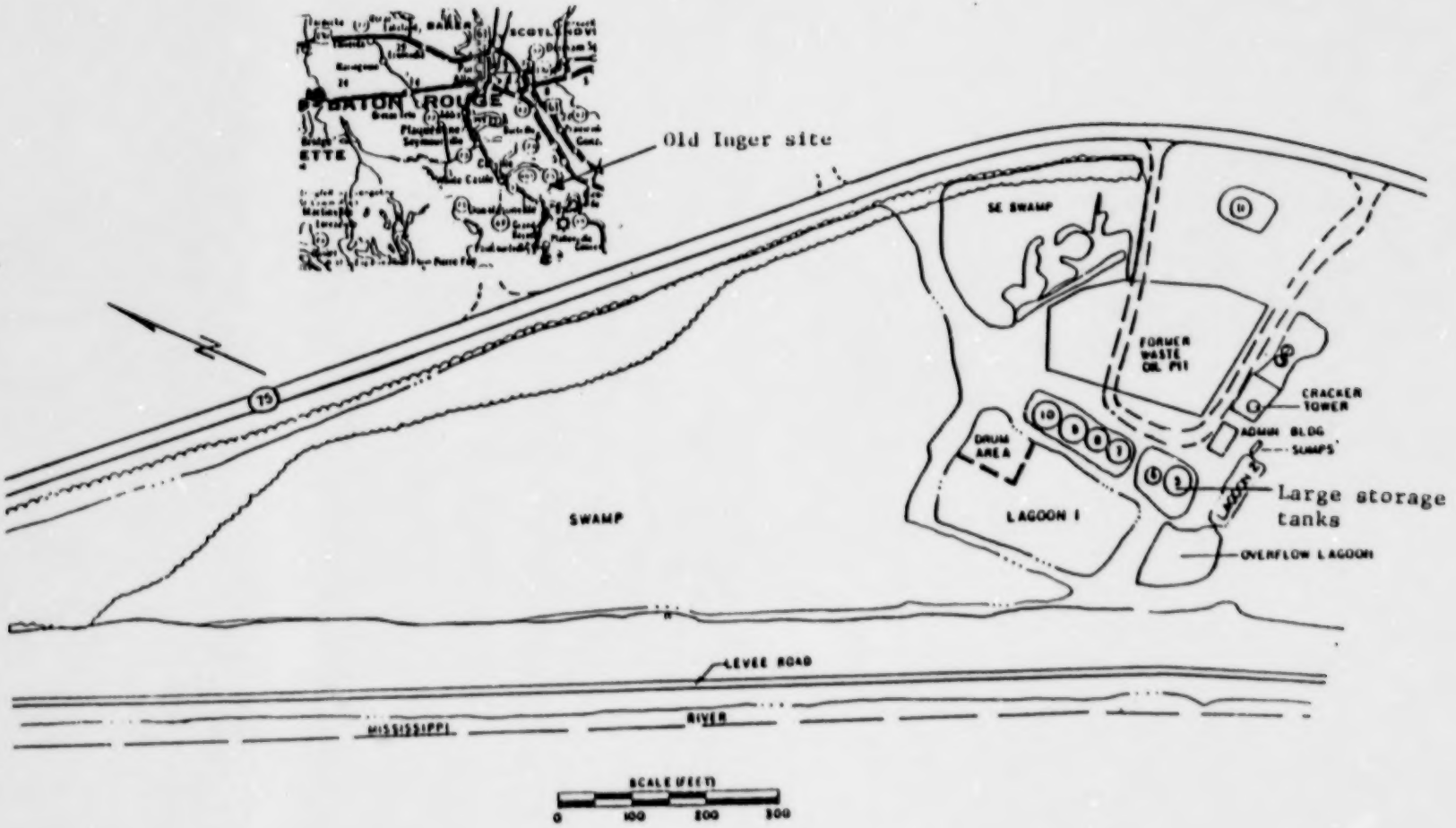

FIGURE 4. OLD INGER REFINERY, SITE LOCATION AND SITE PLAN (FROM LAW ENGINEERING TESTING COMPANY).

The site contains a waste lagoon (Figure 4), approximately 240 feet long and 150 feet wide, which has received several wastes from oil refining processes. This lagoon is only accessible on foot except for the northeast corner, where a light truck may be able to reach the edge of the berm. Presently, the lagoon is filled to within 6 inches of the top and is composed of three layers:

1- A top layer, approximately 1.5 feet thick, composed of a floating oil emulsion.

2- A middle layer of oil-contaminated water that is from 3 to 8 feet thick.

3- A bottom layer of unknown thickness, composed of oil sludges and debris.

The top layer has a thin hardened film that allows small objects such as rocks and sticks to roll across the lagoon surface when thrown. This thin film apparently allows rainwater to penetrate and gases to escape, but does not permit any appreciable evaporation of water from the lagoon. Piercing through this top layer are long 2" x 4" beams, several hundred small bottles, and approximately fifty 55-gallon drums. An analysis of chemical compounds contained in the lagoon revealed the presence of a large number of petroleum-derived compounds including a series of long-chain saturated hydrocarbons, polynuclear aromatics, phenols, aromatics, and phthalate esters (32).

The berm around the lagoon is approximately 5 feet high and 8 to 12 feet wide at the base. The width at the top is between 1 and 3 feet, just barely wide enough to allow one person to walk the perimeter. Materials used to construct the berm appear to consist of local earth materials which are silty and sandy clays. The average vertical and horizontal permeability of these soils is about 1×10^{-5} cm/sec (10 ft/yr) (33). It is not known whether any compaction techniques were used during construction or if any efforts were made to prevent sand seams from forming. Furthermore, the north and west outside toe of the berm is covered with approximately 1 to 1.5 feet of water from an adjacent swamp. This swamp, which was contaminated by a breach in the lagoon berm in 1978, extends about 1500 feet north of the lagoon and connects with a large pasture by an overflow pipe that runs under Louisiana Highway 75. Since the 1978 spill, the swamp has periodically been contaminated by lagoon fluids seeping through a deep notch in the top of the berm (25). This notch has recently been repaired.

Until November, 1983, Federal and state officials believed that the liquid level in the lagoon was fairly constant, subject only to overtopping from rainwater (25). In July of 1983, an emergency action was conducted at the site to create about 2 feet of freeboard by pumping approximately 300,000 gallons of untreated lagoon liquid into three on-site tanks. However, in late November, the area received several inches of rain and the fluid level of the lagoon dropped about 3 inches (25). Presently, there is no confirmed explanation for this drop; it is still under investigation. Prior to the drop in fluid level, studies were being made on alternative approaches to prevent the lagoon at Old Inger from overtopping.

Cost of a Floating Cover at Old Inger

Initial cost estimates for installing a floating cover over the Old Inger lagoon were low, i.e., between $2.50 and $3.50 per square foot (3-20). However, when all the site conditions were evaluated and provided to eleven cover installation companies, only one cost estimate of between $5.50 and $6.50 per square foot was received (12). Assuming a design area of approximately 36,000 ft^2 for the Old Inger site, the cost of a floating cover would be approximately $250,000. This includes the OR-EPA material cost (about $1.50/$ft^2$); the combined costs of the patented float system and gas collection system (about $1/$ft^2$); the installation costs for field seaming, float insertion, and anchoring (about $1.0/$ft^2$); and research and development costs for designing a site-specific anchoring and float system for the cover ($2 to $3/$ft^2$) (12). These costs would have been lower if a less expensive cover material such as Hypalon ($0.70/$ft^2$) could have been used, and if site access and berm stability problems were not present. It is estimated that these factors almost doubled the cost of the cover system for the Old Inger site.

Alternative Solutions for the Old Inger Site

Other methods for controlling the potential overflow from the lagoon at Old Inger were evaluated. Cover systems made from steel, aluminum, and wood were rejected because, at $10 to $20/$ft^2$, these systems would exceed the cost of pumping and treating the lagoon wastes. Air supported structural covers were also rejected on the basis of higher costs, which would exceed $8.00/$ft^2$ of covered area (22). Inflatible covers were rejected because the

lagoon berm at the Old Inger site would probably not withstand the pressures that occur at the perimeters of these covers. Also, these covers require operation and maintanance of air pumps which would not be convenient for the Old Inger site.

Two additional alternatives considered for the Old Inger situation included "no-action" and continued periodic pumpdown/treatment as required. The "no-action" alternative would require no expenditures but would result in an increase in the level of contamination in the swamp surrounding the Old Inger site. The pumpdown/treatment alternative would cost approximately $110,000 each time, assuming that 2 feet of liquid (i.e., approximately 540,000 gallons) would be removed at an average cost of $0.20/gallon. If the level of the lagoon had not dropped during recent rain events and if 3 years were required for complete cleanup of the site, it is estimated that the lagoon would require at least seven pumpdown/treatment operations for an approximate total cost of $770,000. (This is based on 60 inches of annual rainfall and virtually no evapotranspiration from the lagoon due to the floating oil emulsion layer). Therefore, a floating cover would have been less expensive (at $6.5/ft^2, the total cost would be approximately $250,000) than seven pumpdown/treatment operations at the Old Inger site if the level of the lagoon had not dropped.

CONCLUSIONS

Presently, the most common method of preventing overtopping of abandoned waste lagoons is pumpdown/treatment of the upper 2 feet of waste liquid. Costing between $0.10 and $0.40/gallon, this method can be expensive,

especially if it must be performed several times prior to final cleanup of a site (1). Floating covers can be a more economical alternative; however, costs are extremely dependent on site-specific factors. Covers generally cost $\$3.50/ft^2$ (3-20). Assuming that the combined cost of pumpdown, transportation, and treatment is $0.20/gallon; the price for one operation would be about 15 percent less than that for a floating cover on the same lagoon. This cost relationship holds true for any size lagoon assuming vertical lagoon walls and 2 feet of impounded liquid is pumped. Therefore, if the combined costs of pumpdown and treatment exceed $0.23/gallon (i.e., $0.20/gallon plus 15 percent), or if pumping is required more than once, then a floating cover may become the most cost-effective method of preventing overtopping of a lagoon. However, it is again emphasized that adverse site conditions may significantly increase the unit cost of a floating cover.

The engineering considerations associated with site conditions at the Old Inger site almost doubled the normal cost of a floating cover. However, this cost increase would not have caused the cost of a floating cover to rise above the costs estimated for pumpdown/treatment operations if the level of liquid in the lagoon had not dropped. The drop in lagoon liquid level at the Old Inger site is still under investigation, and unless site conditions change again, neither a floating cover nor pumpdown/treatment operations will be needed at the site.